THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

The underground mines of Minas de Matahambre, S.A., in the Province of Pinar del Rio, Cuba, are equipped with three vertical shafts. The No. 3 Shaft is a three-compartment, timbered unit. Early in 1953, the mine management decided to deepen No. 3 Shaft from the 1800 to the 3400 level, a distance of 2,000 ft.

A contract was awarded in April, 1953, to Centennial Development Company of Eureka, Utah, to do the work. The first blast was fired on July 2, 1953, and the last concrete was poured on June 20, 1955.

Please turn to page 133 for a description of No. 3 Shaft and the various operating details involved in this difficult construction project.

• • •

A 12-page pictorial spread, beginning on page 138, depicts the inspiring industrial grandeur of world-famous Bingham Canyon, the mammoth open-pit mine of Kennecott Copper Corporation, 30 miles from Salt Lake City, Utah. Encompassing an area of 933 acres, it is one of the largest open-pit copper mines in the United States.

The story of Bingham Canyon is as fascinating as is the vast amphitheater itself. Historically, mining activities began in 1863, when soldiers of the Third California Infantry, stationed at Fort Douglas, were the prospectors. Their commanding officer, General Patrick E. Connor, encouraged his men to seek metals of all kinds in the area.

Thirty-five years later, Daniel C. Jackling, a young mining engineer from the Missouri School of Mines, estimated that the property contained 12 million tons of two per cent copper ore. Mr. Jackling proposed that the ore be mined by the open-cut method. His proposal was met with ridicule.

In June of 1903, Utah Copper Company was organized, and in April of the following year underground mining was started. Three years later, it was decided to convert from underground operations to the open-pit method of mining, as proposed by Daniel C. Jackling in 1898.

From the beginning of mining operations in 1904 to the present, approximately 1½ billion tons of ore and waste have been cut away from the Bingham Canyon property. The following figures give some indication of the immensity of the canyon: the bottom level is 5,740 ft. above sea level; the top west level is 2,060 ft. higher; the lower levels are about 50 ft. high; the upper levels, 70 ft.; all of the levels average 65 ft. in width. Out of this vast pit, which resembles a huge football stadium, Kennecott Copper Corporation produces 30 per cent of all new copper mined in the United States and 10 per cent of the free world's reported primary production.

Each day's mining involves the removal of 240,000 tons of ore and overburden, broken loose by the skillful use of dynamite and blasting supplies. For every ton of ore mined, more than 1½ tons of rock and conglomerate must be removed and disposed of in nearby gulches.

Holes 24 to 28 ft. deep, spaced on 20-ft. centers, are drilled into the toe of a bank, or working face in the mine. Single rows of holes are drilled vertically up to 28 ft. deep in the higher bank sections, with the spacing between holes averaging 23 ft. After blast holes are drilled, hollow copper pipes are inserted in the holes to expedite the loading, priming, and stemming of each charge of dynamite and to provide an added safety factor.

A monument to the skillful use of dynamite and modern mining methods, Bingham Canyon is universally recognized as an outstanding engineering achievement.

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VOL. 33 NO. 5 SEPTEMBER-OCTOBER, 1955

BPA

INTEGRAL TYPE — Designed for production drilling, the Integral Type is used in combination with the CP-32 AW Sinker for general Airleg work and the CP-59W Sinker for the harder formations and deep-hole drilling. Available with feed cylinder of aluminum alloy. Has push button release at both ends of the sinker handle.

these two CP

ATTACHABLE TYPE — Converts standard CP Sinkers for lateral or overhead drilling. Used with the CP-39 Sinker for soft to medium formations; the CP-32A Sinker for general Airleg work; the CP-59 Sinker for hard formations or deep-hole drilling. All sinkers recommended for use on Attachable and Integral Airlegs are available with optional hooded front head that reduces weight and prevents chuck spray.

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INTEGRAL TYPE is quickly changed over for regular Sinker drilling. Operator simply loosens quick-disconnect nut on the Airleg, dismounts the Sinker and adds his "T" handle.

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When Dynamite Came To Alter The World

CHARLES F. THOMAS*

Crude methods were used by ancient craftsmen,
Who mined in dark cavern or pit;
But nations have thrived with wealth from their toil
And welded Earth's metals with wit.
Time was of small moment; for haste, little need;
No striving for plaudit's vain ring.
The measure of work meant count of the men,
Weak slaves held in liege to a king.

Rock chipped from tunnel, channel, or face,
Or fines loosed with sledge or a moil,
Were mucked with a paddle hewn from a log.
Or handpicked with infinite toil,
And wearily lugged up ladder or path
In basket or crude copper pail.
No drive marked the task of lab'ring hordes.
Save dread of an overseer's flail.

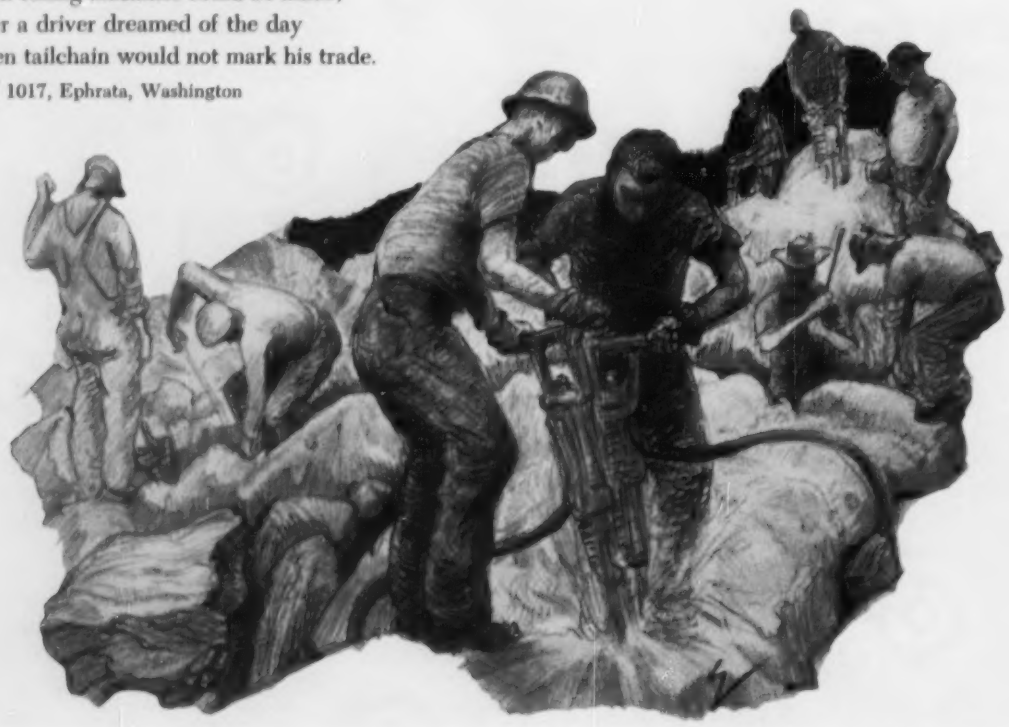
Wood rollers eased stone from far quarry mines
To temple or pyramid's base,
While wheels, crudely shaped from ends of a log,
Rolled laden carts at a snail's pace.
Tired men, pushing cars, envisioned the ways
Work-easing machines could be made;
But never a driver dreamed of the day
When tailchain would not mark his trade.

*P.O. Box 1017, Ephrata, Washington

Soon mule and the horse supplanted weak man
In dragging mine cars from the drifts.
Steel rails and iron wheels sped traveling loads
And stepped up the output of shifts.
Mine haulage has changed from baskets to belts,
Moved mining from slow work to fast.
Soon old wooden sprags with tailchains and shafts
Will lay with lost tools of the past.

When dynamite came to alter the world
And awakened mankind with its urge,
New planning and glory crowded men on
To far-reaching heights in its surge.
Soon "rock in the box" became the work cry
From Yukon far down to the Rand.
"Jack, fill up your shovel or get your coat!"
Tough shifters in Butte would command.

With mucking machines, like fierce, fighting beasts,
No muckpile is ever too tough;
Yet tenderfeet smile when stories are told
How oldtimers "mucked off the rough."
Hardrockers have changed, in ways, with the trends,
Kept pace with new methods and speeds,
Break records each day in progress and costs,
And pridefully boast of their deeds!



HEADFRAME AND HOIST HOUSE: Shown here are the headframe and hoist house at Shaft No. 3 where shaft-sinking operations were carried on. The shaft was deepened from the 1800 to the 3400 level, a distance of 2,000 ft.

DEEPENING SHAFT No. 3 AT MINAS DE MATAHAMBRE, S. A.

Excellent shaft-sinking progress was consistently maintained with the bench method of drilling and blasting, despite adverse ground conditions

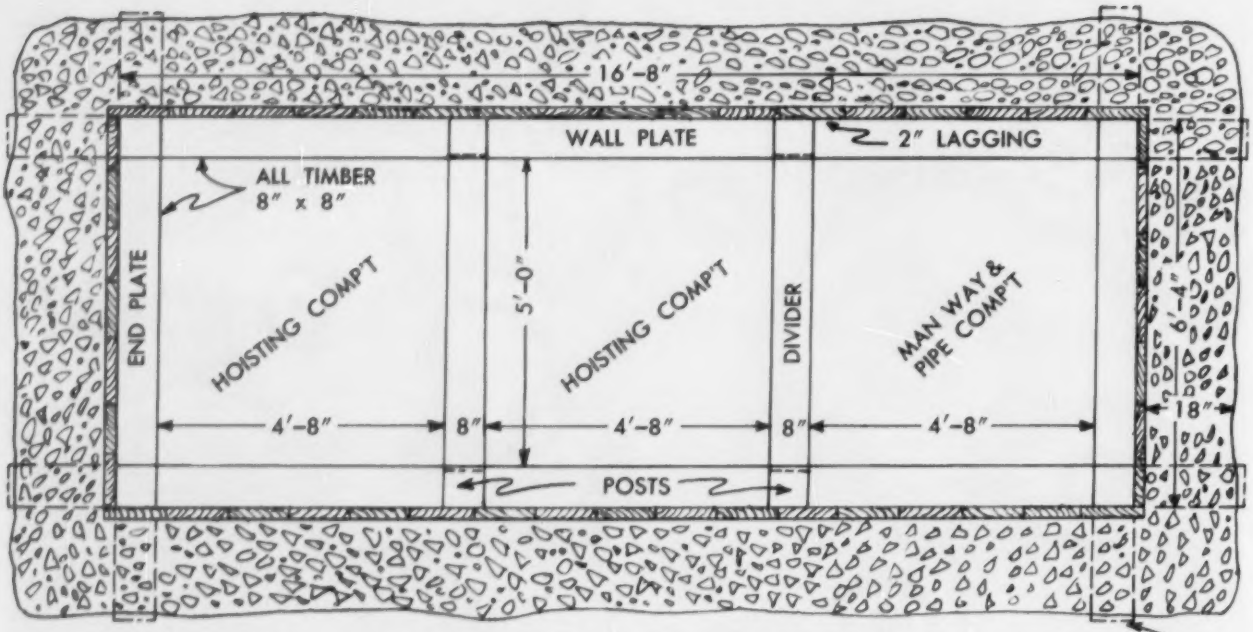
RICHARD P. GERWELS*

MINAS DE MATAHAMBRE, S.A., is located 100 air miles west-southwest of Havana, Cuba, six miles from the north central coast of the Province of Pinar del Rio.

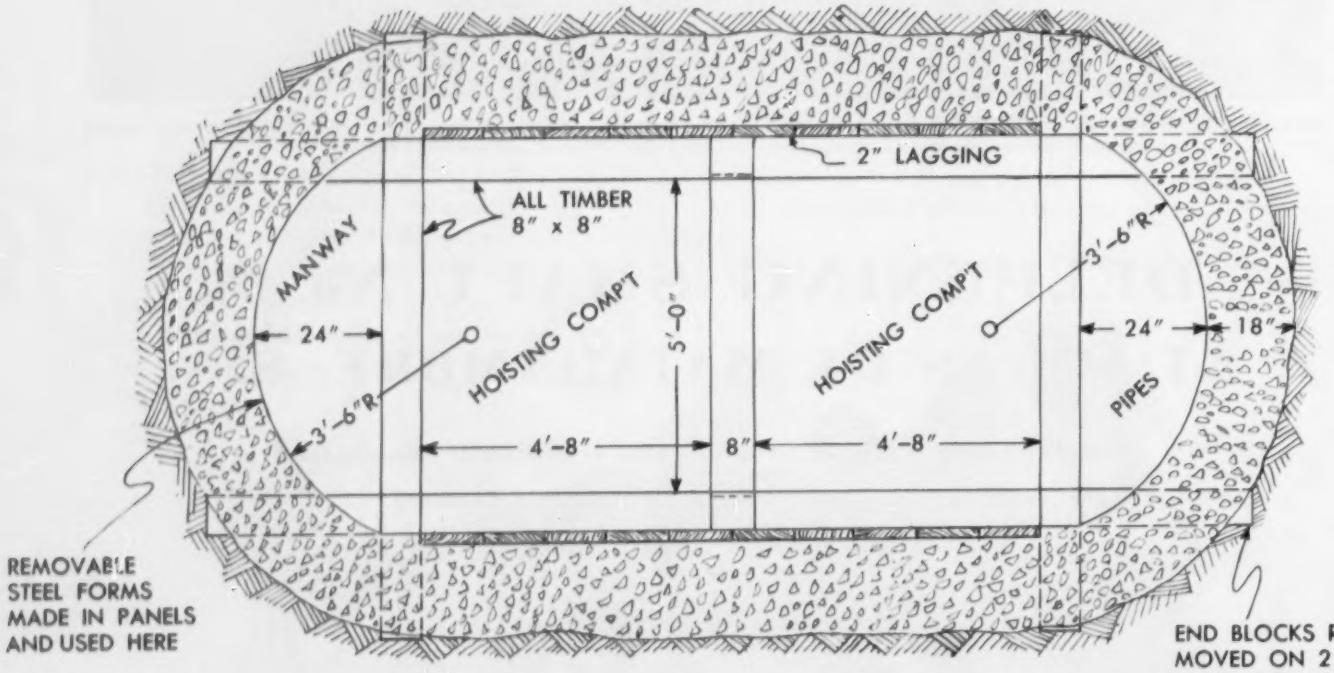
Shaft No. 3 is on the northeasterly fringe of the mining area N. 65 degrees E., 1,250 ft. from Shaft No. 2. During various periods from April, 1929, to November, 1948, the shaft was sunk from the surface to the 1800 level, a distance of 1,300 ft. The collar of the shaft is 300 ft. above sea level, with the 1800, 2600, 3000, and 3400 levels approximately 1,000, 2,200, 2,600, and 3,000 ft. below sea level, respectively.

The decision to sink Shaft No. 3 from the 1800 to the 3400 level, a distance of 2,000 ft., was made in early 1953. The primary objectives were to provide more extensive exploration work, a service shaft for the lower levels, a production shaft for use in an emergency, to augment ventilation, and as a secondary exit from the 2100 level downward. With these objectives realized, the overburdened No. 2 Shaft would be in a position to devote more time to production and to its repairs.

*Chief Engineer
Minas de Matahambre, S.A.
Matahambre, Province of Pinar del Rio, Cuba; engineer in charge of sinking operations at Shaft No. 3 after January 1, 1955



Original design of Shaft No. 3. Scale: ⅜ in. equals 1 ft.



Modified design of Shaft No. 3. Scale: ⅜ in. equals 1 ft.

In April, 1953, a contract was signed with the Centennial Development Company of Eureka, Utah, to deepen Shaft No. 3. The first round of drill holes was blasted on July 2, 1953, and the last concrete was poured on June 20, 1953. The shaft-sinking operation was under the supervision of William J. Bridgeman. The entire crew of 16 men, including the hoistmen on the project, was furnished by the Centennial Development Company.

Shaft Data and Modification of Design

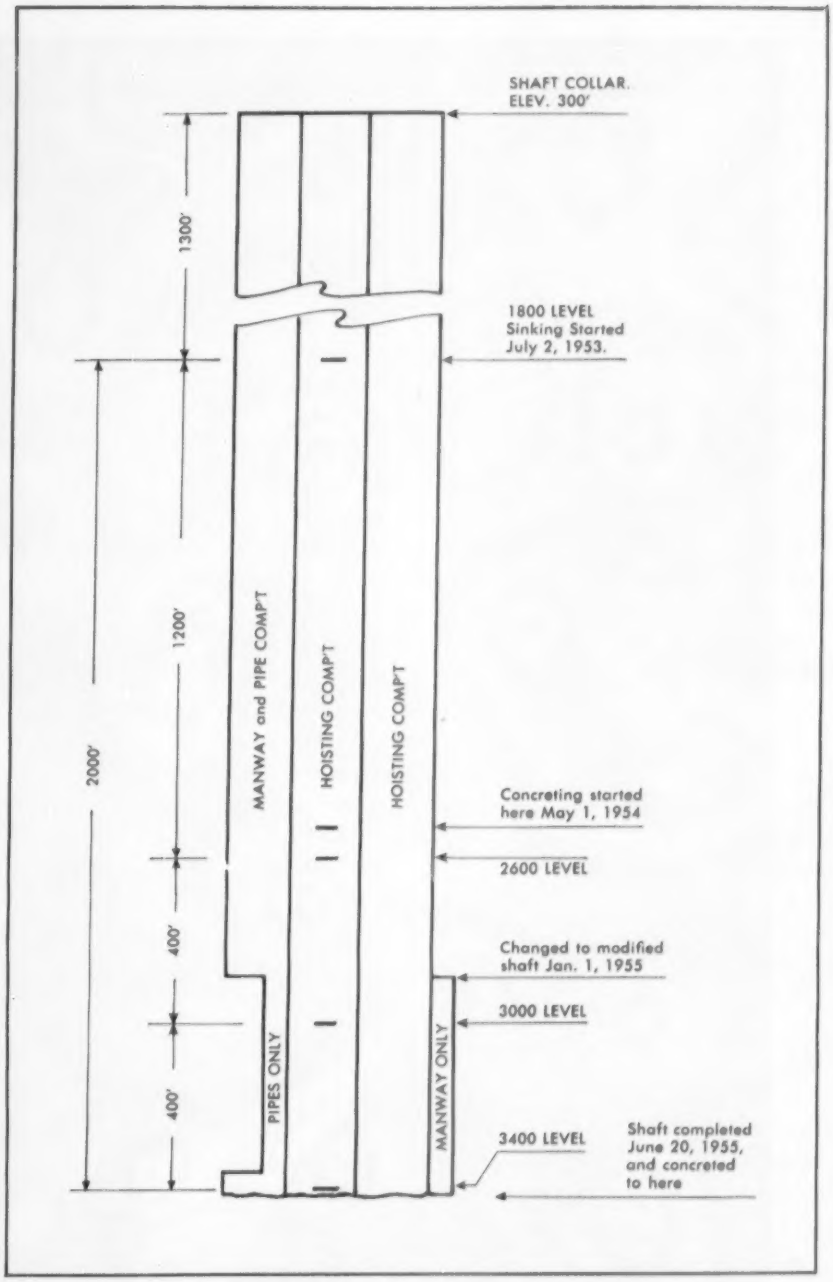
Shaft No. 3, to its point of modification, is of standard three-compartment design, with two hoisting compartments and a combination manway and pipe compartment at the southerly end. Shaft sets, spaced at 5-ft. centers, are 8 by 8-in. Honduras pine, pressure-treated with an arsenical solution to prevent decay. Each compartment is 4 ft. 8 in. by 5 ft. inside, making the outside dimensions of the shaft 16 ft. 8 in. by 6 ft. 4 in.

Because of bad ground conditions,

the design of the shaft was modified late in 1954 to a semi-elliptical type. The modification moved the manway to the northerly concave end, left the two hoisting compartments unchanged, and left the pipe compartment on the southerly concave end. This change was made 294 ft. below the 2600 level on January 1, 1955.

The anticipated advantages of the modified design were: (1) depending on the point of applied pressure on the sides, the maximum moment would be lessened from a 35 per cent minimum with a concentrated load at the center to 55 per cent with a uniform load the entire length of the sides; (2) a shaft better-suited to existing and anticipated ground conditions and more capable of withstanding both side and end pressure; (3) labor and material savings of about 20 per cent; (4) avoids the possibility of sinking an offset shaft from the 2600 level, with its attendant operational problems and additional expense.

The disadvantages are: (1) 20 per cent less ventilation area; (2) modification of existing shaft sets; (3) decrease in size of the manway and pipe compartments and movement of the former to where it will require men who may use it to cross the hoisting compartments where the change occurs. Provisions are being made to minimize this safety hazard.



Longitudinal vertical section of Shaft No. 3 — looking southwesterly

Surface Installations

The first 1,200 ft. of this shaft was sunk with the existing Ottumwa hoist wrapping a 1-in. rope on double 4-ft. drums and driven by a 200-hp. A.C. motor. With this arrangement, rope speed was about 500 ft. a minute. The headframe was a 45-ft. steel structure. However, the deepening activities necessitated the buying of a new hoist to operate at an ultimate depth of 3,700 ft. with a 21,000-lb. pull on a 1⅛-in. rope, and a maximum speed of 1,500 ft. a minute.

In March, 1953, an order was placed with Nordberg Manufacturing Company for an 8-ft. cylindrical double-drum hoist driven by a 500-hp. General Electric A.C. motor at 720 r.p.m. This decision also involved a larger headframe and a new hoist house. Both of these had to be located and erected so as not to interfere with shaft-sinking progress. The site chosen was on the opposite side of the shaft from the old facilities because of better hoist foundation and less interference during erection of the new headframe.

The headframe, an 85-ft. steel structure, was originally located at the Eureka Standard Mine in Utah. It was dismantled and shipped to Matahambre. Erection at the new site was accomplished with Dardelet rivet bolts and welding. The 30 by 60-ft. structural steel hoist house and headframe foundations were designed by Matahambre's engineering staff. Erection of the hoist house was completed in December, 1953, the hoist installation and headframe erection by March, 1954, with the change-over to the new hoist on March 30. The new hoisting facilities reduced the shaft-servicing and mucking time considerably.

Compressed air for the operation was furnished by a Gardner-Denver

(Continued on page 151)

FRANK R. MILLIKEN

Frank R. Milliken

VICE PRESIDENT

KENNECOTT COPPER CORPORATION

A Biography

FRANK R. MILLIKEN, at the age of twenty-one, began his career in the mineral industry as a metallurgist and mill superintendent with a lead and zinc mine in New Mexico. His personal qualities and resourcefulness, plus thorough training in the fundamentals, capacity for hard work, and exceptional organizing ability, were recognized by successive advancements to positions of responsibility. Three years ago he was chosen by the management of Kennecott Copper Corporation to be vice president in charge of Western mining divisions, its South African mining, and the Braden Copper Company.

Frank was born in Malden, Massachusetts, on January 25, 1914, the son of Frank R. and Alice Gould Milliken, of Scotch ancestry. He received his formal elementary education in the Milton Junior High School and the Milton High School. From the age of thirteen through high-school years, Frank was the after-school and summer office boy and bookkeeper at the Blue Hill Bank and Trust Company in Milton, Massachusetts.

Following his graduation from high school, he enrolled in the Massachusetts Institute of Technology in Cambridge. He was graduated from M.I.T. in the class of 1934 with an S.B. degree in mining engineering. His extracurricular college activities included captain of the hockey team; a participant in wrestling matches; membership in Tau Beta Pi, an honorary engineering society; and an associate of Sigma Xi, an honorary science-research society. During summer vacation months, he played baseball on several teams representing Canadian mining companies.

In 1935, Frank went to work for Peru Mining Company at Deming, New Mexico, as metallurgist and mill superintendent. The following year, he became associated with General Engineering Company at Salt Lake City, Utah, as chief metallurgist. In addition to his ore-testing duties, he helped to direct the design, construction, and initial operation of mines and mill plants throughout the world.

In 1940, Frank joined Utah Copper Company as an experimental engineer. Early in the following year, he moved to Tahawus, Essex County, New York, to become mill superintendent of the McIntyre Development of National Lead Company. This operation was a 5,000-ton-per-day ilmenite and magnetite mine, mill, and sinter plant. Subsequently, he was advanced to assistant manager and manager of the activities at Tahawus.

In 1949, Frank was brought in to National Lead Company's headquarters in New York City as assistant manager of its Titanium Division. On this assignment, he concentrated on the company's mining of titanium, the production of titanium pigment, and research and development of titanium metal. He was also made a member of the mining committee of the company.

Mr. Milliken was honored by the American Institute of Mining and Metallurgical Engineers in 1952 by being chosen as the recipient of the Robert H. Richards award, in recognition of his significant contributions to titanium metallurgy and mine management.

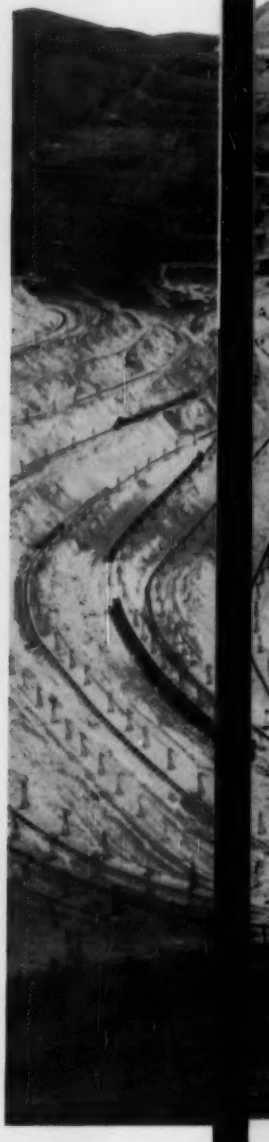
Also, in 1952, Mr. Milliken became associated with Kennecott Copper Corporation as vice president, handling its Western mining divisions (Utah, Nevada, Ray, Chino), Braden Copper Company, and South African mining.

Frank R. Milliken married Barbara Kingsbury at Deming, New Mexico, in 1935. They have two sons, ages thirteen and seventeen. The family home is at 20 Beach Drive, Noroton, Connecticut.

Frank's club affiliations include the Wee Burn Country Club, the Noroton Yacht Club, and the Mining Club of New York City.

Frank R. Milliken – mining engineer, metallurgist, executive – knows the value of relaxation: casting for trout in nearby streams and playing golf with his many friends and associates.

BINGHAM CANY



It looks like an oversized football stadium,
The kind of thing Paul Bunyan might have dished out
In an hour, without the help of his blue ox, Babe.
Ordinary Man took 50 years to do the job,
Moving a mountain to one side,
Blasting and digging and hauling
Almost a half-billion tons of ore.

This harvest eventually became (and still becomes)
Millions of miles of telephone wire,
Pipes and tubing, pots and pans,
Or vital parts of houses and cars,
Radios, airplanes, and electric motors.
Even in the majesty of the mountains,
This hole in the earth is a mighty big thing!

On succeeding pages are presented a series of photographs of Kennecott Copper Corporation's famous open-pit mine in Utah, made especially for The Explosives Engineer by W. M. Rittase, nationally known industrial photographer, and Stanley Kershaw, whose photographs are part of the scenic West.

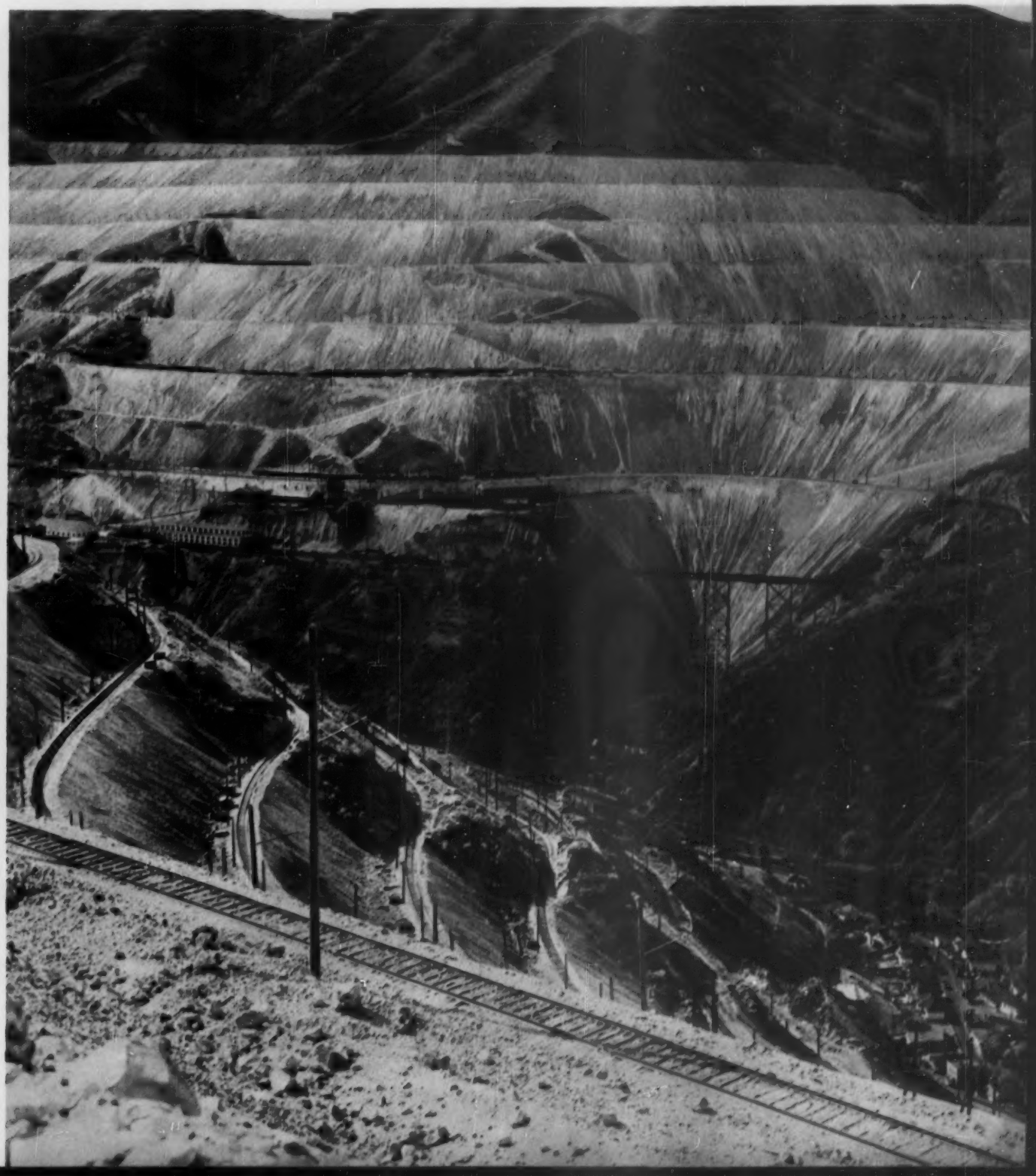
Y O N

Since 1904, when mining operations were started at Bingham Canyon, approximately 1¼ billion tons of ore and waste have been cut away from the earth, leaving giant steps, or benches, along the sides. Today, out of this vast amphitheater in Utah, encompassing 933 acres of operating area, 30 miles from Salt Lake City, Kennecott Copper Corporation produces 30 per cent of all new copper mined in the United States, and 10 per cent of the free world's reported primary production.

Man is dwarfed beside the immensity of Bingham Canyon. The bottom level is 5,740 ft. above sea level; the top west level is 2,060 ft. higher. The levels average 65 ft. wide. The height of the lower levels is

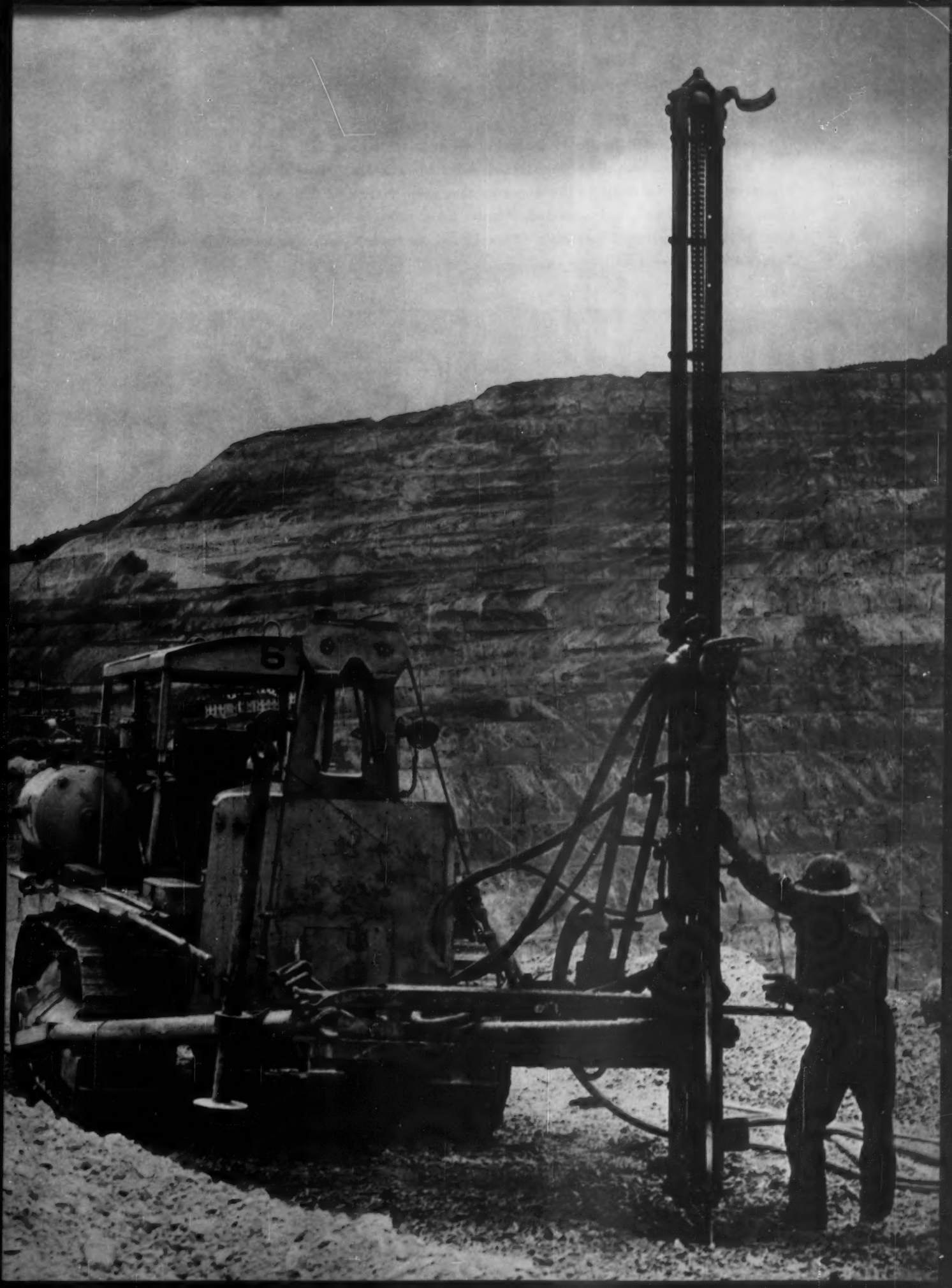
approximately 50 ft., the upper levels 70 ft. With dynamite, power shovels, and strings of 100-ton railroad cars, each day's mining involves the removal of about 240,000 tons of ore and overburden.

For every ton of ore mined, more than 1½ tons of rock and conglomerate must be removed and disposed of in nearby gulches cutting the walls of the main canyon. New slopes gradually rise where disposal areas receive mine waste, taking on the appearance of industrial grandeur. A part of the town of Bingham Canyon is shown along the canyon floor.



Tractor-mounted wagon drills sink horizontal blast holes 24 to 28 ft. deep, spaced on 20-ft. centers, into the toe of a bank. The holes are angled downward to finish at about 5 ft. below the grade level of the bench.

Single rows of vertical holes are drilled up to 28 ft. deep in the higher bank sections of the mine. The spacings between the holes average 23 ft. This type of vertical-hole drilling accounts for approximately one-third of all blast-hole operations.



Without the controlled power of dynamite, the efficient mining techniques developed by Kennecott would be impossible. After blast holes are drilled, hollow copper pipes are inserted in the holes so that each charge of dynamite can be safely loaded, primed, and stemmed. Results from primary blasts average 2,200 tons of broken material per hole (22 railroad carloads), with approximately 240,000 tons blasted daily.

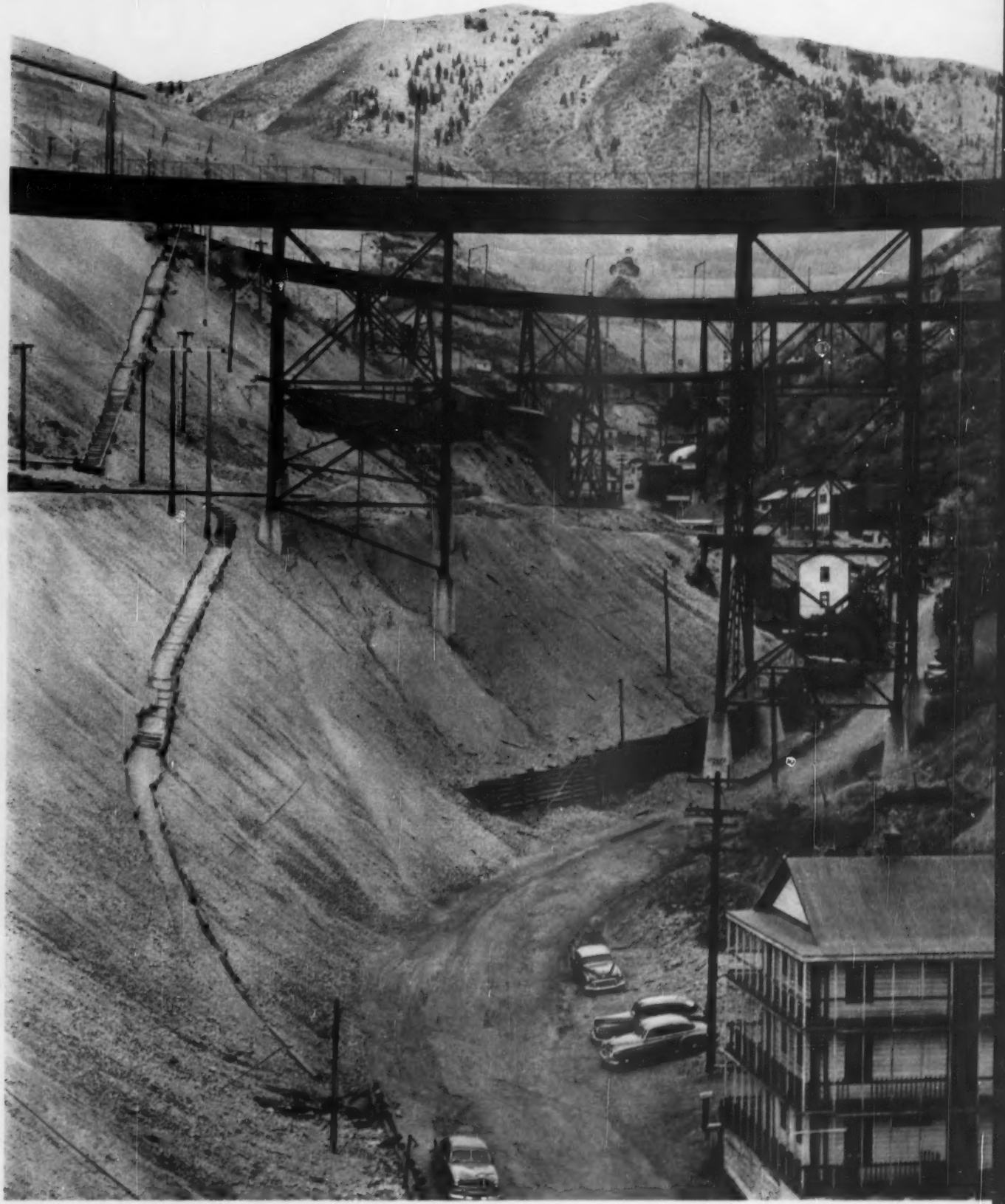
Following a carefully planned schedule, each group of workmen keeps one step ahead of the group behind it. The drillers and blasters precede the shovel operators who, in turn, are followed by the drillers. Before loading the broken ore at a newly blasted face, loose and hanging sections of broken rock are pried down from the top of the bench to assure safe working conditions on the level below.

The giant dipper of a 5-cu. yd. electric power shovel ladles the blasted ore into 100-ton railroad cars. By 1955, Kennecott had 38 electric shovels in operation, loading trains of 13 to 21 cars which are then snaked through the canyon by electric locomotives to a main assembly yard. Steel supports for the miles of overhead power cable form a fencelike pattern on every level around the contours of the mine.

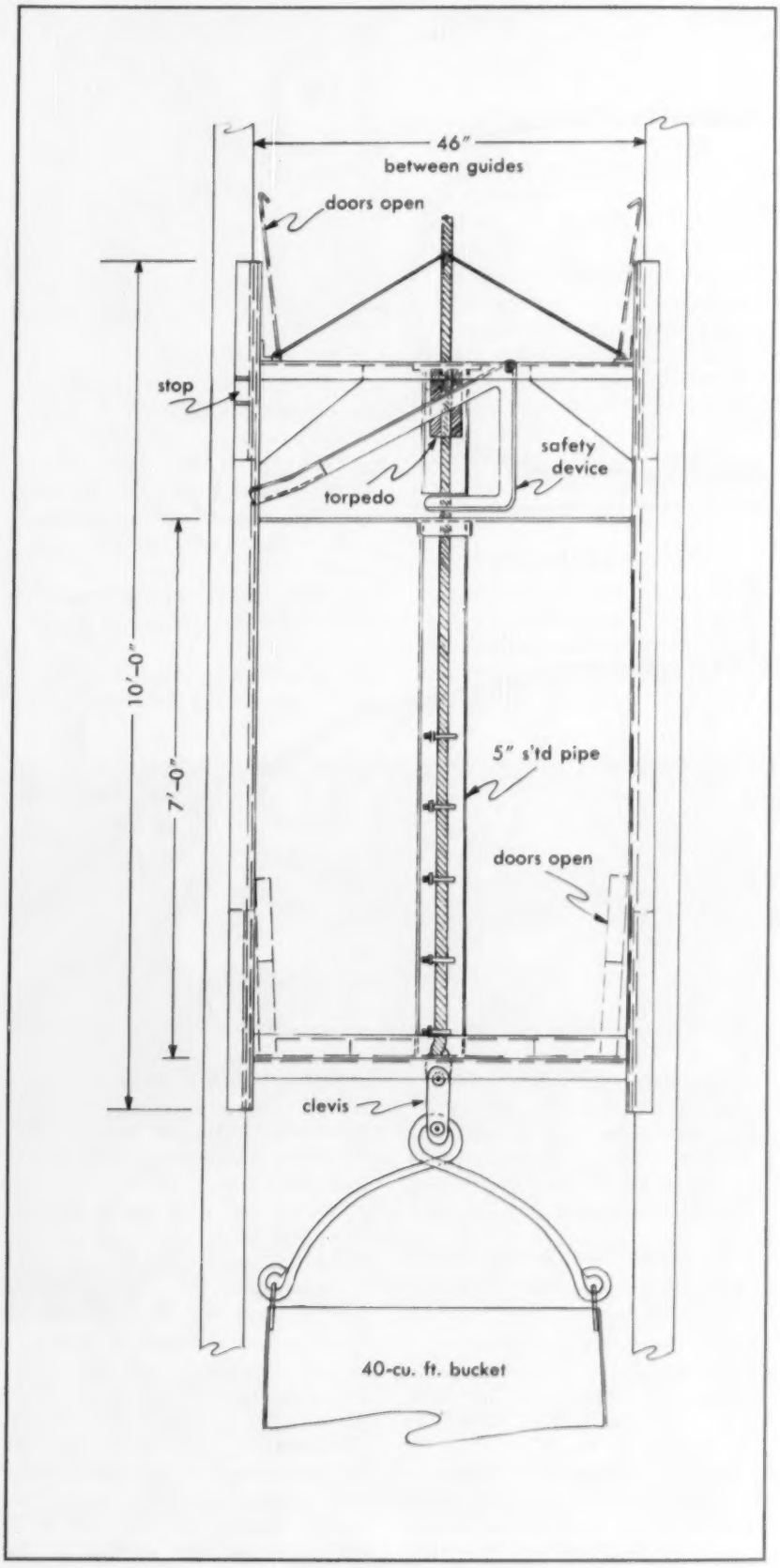
Railroad operations, complete with trainmen, switches, block signals, and repair shops, are important in the handling of ore and waste. A network of 174 miles of standard-gauge track is constantly being expanded to reach new levels being developed. As mine levels change, the 3,400 portable steel towers, bearing transmission and trolley lines, are moved to meet new track alignments.

At the mouth of the canyon in the main assembly yard, trains of 100-ton-capacity cars are made up and hauled to the modern Arthur and Magna mills. At the mills, copper concentrate is produced by the flotation process. The concentrate contains about 31 per cent copper and small amounts of molybdenite, gold, silver, and some other metals.

Travel between the man-made cavity in Bingham Canyon and the man-made mountains of waste called for the construction of bridges from one level in the mine to the opposite side of Carr Fork Canyon and to disposal areas. The rumble of trains overhead is as familiar a sound as the blasting at the end of each day.



Some mine employes make their homes in Copperton, a town of modern residences located at the entrance to Bingham Canyon. In this community of typical suburban houses, there is probably greater use of copper for pipes, rain gutters, flashing, and heat ducts than in comparable houses elsewhere in the nation.



The sinking cage

Deepening Shaft No. 3

(Continued from page 135)

600-c.f.m. mobile-type compressor through a 4-in. line. Other surface installations consisted of an office, a cook house, and a bunk house.

Geology

The country rock at Matahambre consists of an immense, but undetermined, thickness of shale and indurated shale, quartzitic sandstone, and interbedded members of these two types, referred to as the Cayetano formation of Cretaceous (?) age. The prevailing local strike of the beds is N. 50 degrees E., with a dip of 40 to 60 degrees northwest. More localized variations are common. Shaft No. 3 is oriented normal to the strike of the beds.

The decision to deepen Shaft No. 3 was based on the best geologic information available. The local geologic structure is dominated by the Manacas fault, which strikes N. 60 degrees E. Near Shaft No. 2 the fault has a northerly dip of about 85 degrees where it has been exposed over a vertical range of 3,500 ft. Projections indicated a near vertical northerly dip near Shaft No. 3. On the 1800 level the fault is 125 ft. north of Shaft No. 3, and a connecting crosscut on the 2600 level to the shaft crossed the Manacas 50 ft. north. Indications pointed to intersecting or possibly crossing the fault before reaching the 3400 level. This proved to be essentially true when the fault zone was encountered on the northerly end of the shaft at about the 3200 level. Fortunately, however, the fault maintained almost a vertical dip to the 3400 level, which was controlled mainly by rock bolting, and, to a lesser degree, by the concavity of the shaft. Thus, the projected near vertical northerly dip turned out to be a near vertical southerly dip.

The geology of the final 700 ft. of shaft was mapped in detail and this information added measurably in the decision to formulate plans for redesigning the shaft and in the day-to-day operations.

Ground conditions in the shaft were governed by the following: (1) northerly and southerly dipping faults related to the Manacas with possibly some independent structures; (2)

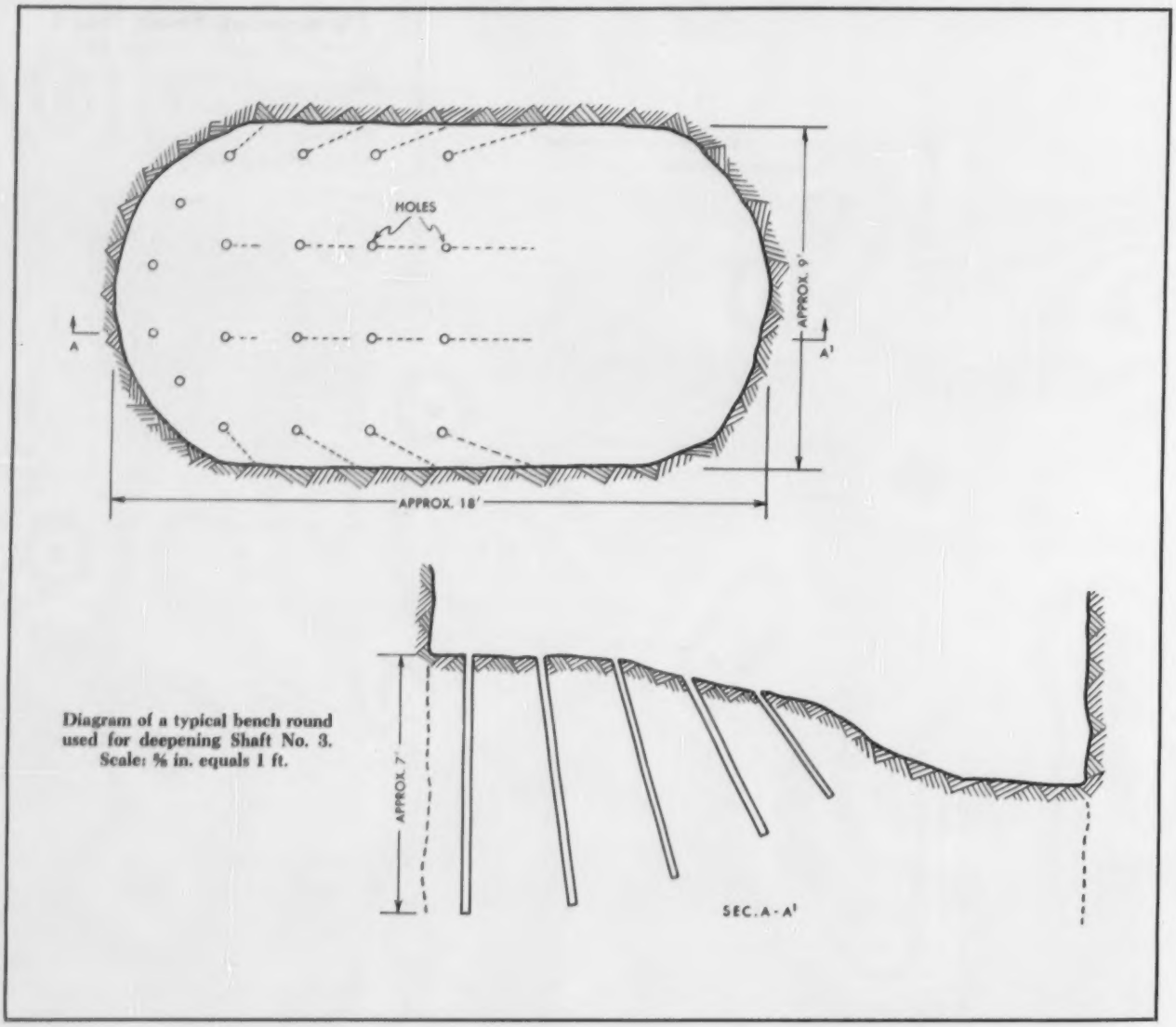


Diagram of a typical bench round used for deepening Shaft No. 3. Scale: ⅜ in. equals 1 ft.

nearness of the Manacas fault which became increasingly important with depth; (3) minor bedding faults and faults associated with initial folding; and (4) stratigraphy in which predominantly shaly sections provided better ground conditions than the interbedded sandy and shaly sections. Without question, it was under the northerly dipping faults (1) that the severest ground pressure and some of the worst ground conditions were experienced by the sinking crew.

Water

The water encountered during sinking operations, with the exception of that hoisted with the muck, was pumped into buckets with an Ingersoll-Rand air pump, hoisted to the surface, and self-dumped into a drain. Quantity varied, depending on the season of the year, from 3 to 7 g.p.m. Of this amount, about 3 g.p.m. came from various places in the newer section of the shaft, and the remainder was seepage into the shaft from the upper part.

Drilling and Blasting

The shaft crew was made up of five men on each of three shifts, working seven days a week. The crew consisted of one lead man, three men in the bottom, and a hoistman. The truck driver was furnished by Minas de Matahambre.

Bench rounds were used exclusively. The advantages of benching were: (1) it provided a sump so that the next round could be drilled with little interference from water, and the bench could be cleaned of muck that would interfere with drilling; (2) it caused less damage to timber from blasting. The disadvantages were doubled setup and smoke time.

Drilling was done with Ingersoll-Rand J-50 Jackhamers equipped with Swedish Coromant ⅞-in. hexagon steel and an integrated chisel-type tungsten carbide insert bit. The steel was in 3-, 5-, and 7-ft. lengths with bit gauges of 1⅝, 1⅝, and 1¼ in., respectively.

Drilling speed depended on the type of rock and rock conditions. However, for a round in shale, the crew usually left the collar at 7 a.m., went below and set up, drilled out, tore down, loaded, blasted, and was back at the collar 1½ hrs. later waiting for the smoke to clear. The number of holes

MATAHAMBRE'S CHIEF ENGINEER: Richard P. Gerwels, chief engineer, prepared this article in cooperation with his associates at Minas de Matahambre.

drilled in a round varied with rock conditions. In the original three-compartment shaft, it was from 25 to 27; in the modified shaft, from 19 to 21. With a 2-in. Ingersoll-Rand detachable bit, the holes were collared deep enough to receive a 10- to 20-in. length of 1¼-in. pipe for casing. Seven-foot rounds were usually drilled, which yielded an average full-bottom advance of 3 ft. per round.

The drill holes were loaded with either Gelamite® 1 dynamite in 1 by 8-in. cartridges or Gelamite 2, 1 by 8 in., primed with Hercules® Regular Delay Electric Blasting Caps. Each blast was fired electrically from the nearest level.

Smoke was cleared and ventilation maintained below each level by means of Coppus blowers, driven by 5-hp. motors, and discharging into a 16-in.-diameter vent pipe. These were mounted in tandem at intervals of about 400 ft. as depth was attained below a level. Shaft No. 3 is downcast, and fresh air was drawn from the nearest connecting level above.

Hoisting and Mucking

During the initial phases of the sinking operation, limited headspace in the headframe contributed to difficulty with swinging buckets striking the wall plates below the sinking cage during hoisting. Occasionally, damage was done to the extent that replacement of a wall plate or lagging was necessary. The trouble was caused by the torpedo's riding on the bottom of the sinking cage, which left about 6 ft. between the torpedo and the bail of the bucket, thus giving a pendulum effect. This trouble was eliminated by designing a new sinking cage, which involved moving the safety device and collaring of the torpedo from under the floor of the cage to near the top. This change left only the clevis between the bottom of the cage and the bucket bail. The cable thimble, clamps, and torpedo were housed in a 5-in. standard pipe built into the cage.

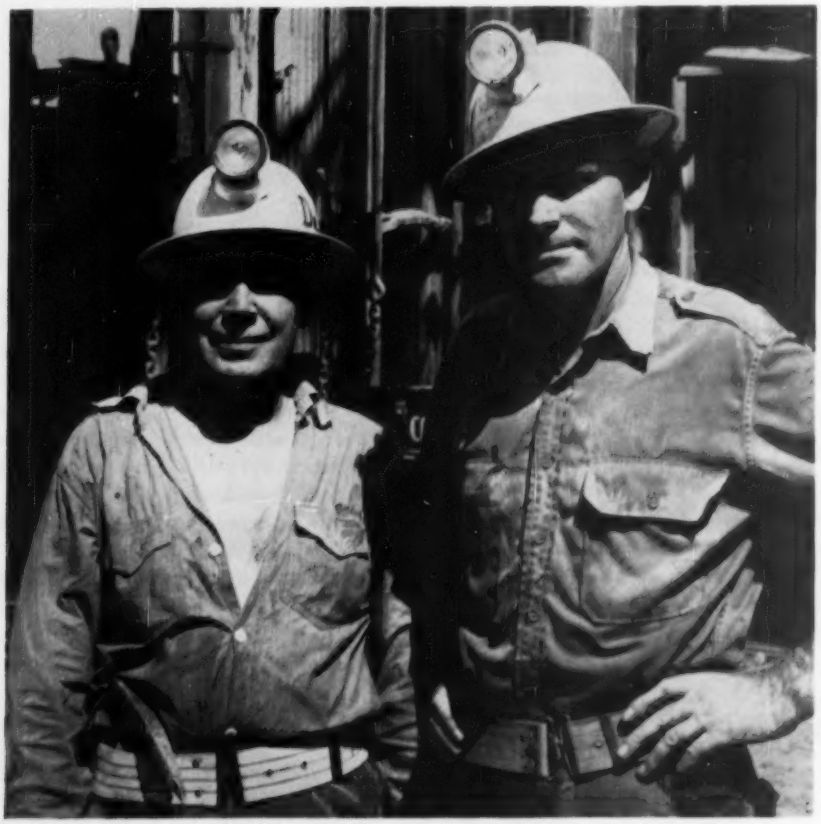
As shaft-sinking operations progressed, the hoisting cycle, with the Ottumwa hoist at about 500 f.p.m., became an increasingly time-consuming operation. However, with the changeover to the new Nordberg hoist in March, 1954, with rope speeds up to 1,500 f.p.m., this trouble was alleviated.

At first, the muck was hoisted in 20-cu. ft. buckets. Soon after sinking activities began, the buckets were changed to 40 cu. ft. and mucking time was shortened considerably.

A Riddell clamshell mucking machine handled all of the muck, except on four separate occasions during March, May, July, and September, 1954, when bad ground conditions made hand-mucking necessary for a few feet. A minimum clearance of about 12 ft. between the bottom of the mucker and the top of the muck pile was necessary for the clamshell to dump into the bucket. Therefore, when ground pressure required installing the dividers in the last two sets, where the mucker normally operated, the Riddell mucker was useless and hand-mucking became necessary.

The mucking machine had three air-driven Gardner-Denver motors, and was operated by one man who sat on the carriage. The carriage operated on a track that rested, generally, on the end plates of the last set of timber in the shaft. The clamshell, manufactured by the Blaw-Knox Company, was a ¾-cu. yd. unit. It proved very effective under the varying rock conditions.

During mucking, one man operated the machine; one stayed in the bottom



UP FROM DOWN UNDER: After inspecting work progress in deepening Shaft No. 3, Matahambre's president, Dr. Ernesto Romagosa, at left, and General Manager Arthur P. Nelson return to company headquarters.

SHAFT-SINKING CREW: The photographer took a picture of some of the men of the Shaft No. 3 sinking crew on their way to the change house at the end of a shift at Minas de Matahambre.

tagging the clamshell; another stayed two or three sets above the mucker at the sinking cage hang-up ringing bells; and the fourth either prepared timber or reinforcing steel at the collar, or made up the explosives charges for the next blast.

The muck was deposited into 40-cu. ft. buckets, which were hoisted to the surface where they were self-dumped into a truck by means of air-operated counter-balanced hinged doors handled by the truck driver.

Timbering and Wall Bolting

Timber for shaft sets was sent down from the collar and was usually installed two sets at a time. The wall plates were suspended beneath the bucket from a sling, with the posts, dividers, and hanging rods going down in the bucket. Wall plates were installed first and temporarily suspended on the hanging rods. Following this, the end plates and posts were installed, the hanging rods cinched up, and the set blocked. This completed a set until the mucking machine was moved below it, and then the dividers were put in. Later, guides and pipe were lowered in the same manner as wall plates and installed in 20- and 10-ft. lengths, respectively. Occasionally, ground conditions made necessary the installation of one set at a time. At such times, the mucking machine was moved down only one set, rather than the usual two. At times, ground pressure necessitated installing the dividers on the last two sets and reverting to hand-mucking.

When bad ground was first experienced in March, 1954, jacket sets were used. When sloughing became excessive, jacket sets, booms, and cribbing were necessary. In the proximity of the northerly dipping faults, ground conditions became worse because of both sloughing and pressure. Here the ground was "alive," so to speak, and pressure of an undeterminable amount was exerted. As an example, on the 2600 level station, bearers made from 15-in. 42.9-lb. steel I-beams encased in concrete for 2 ft. on each end were buckled over a 6-ft. span. It was observed that where pressure was excessive, relieving the ground one or more times tended to stabilize it. In one section of the shaft, the ground was "alive" to the extent that it moved several inches in a matter of days, which caused wall bolts to be buried in end plates.

Slot-and-wedge type 1-in. wall bolts, 5 ft. long, combined with 4-in. 5.4-lb. channels of varying lengths, were used successfully for several months in place of jacket sets. There was no standard pattern for the wall bolts; they were installed under close supervision to meet varying ground conditions. Bolts were installed immediately before or after mucking, and as ground conditions necessitated their installation.

Wall bolting substantially increased the safety of men working at the bottom of the shaft. Also, it allowed longer sections of the shaft to be left untimbered for short periods of time in relatively good ground.

Concreting

Concrete poured totaled 3,800 cu. yd. in 870 lin. ft. of shaft. Of this, 2,000 cu. yd. were poured in the first 370 ft. of the three-compartment shaft, and 1,800 cu. yd. in the final 500 ft. of the modified shaft. On this basis, a 900-cu. yd. savings in concrete was made, representing a savings of $20,000. This result may be attributed primarily to two reasons: (1) better control over ground conditions in the modified shaft because of the smaller cross section, and (2) theoretically 20 per cent less area to be concreted.

The only satisfactory local source of coarse aggregate for the concrete was mined from quartzite beds on the 2100 level. It was crushed to minus 2 in. and washed. Sand, obtained locally, was washed in a rake classifier to remove deleterious material.

Concreting was done in 10-ft. lifts, with an occasional exception because of ground conditions. The concrete, a 1:2:3 mix with an additive for quick strength to offset possible ground movement, gave tests of 1400/lb./in.^{2} in 24 hrs. It was mixed at the collar and

lowered to the pouring platform in 36-cu. ft. buckets, fitted on the bottom with a hinged flap-type door and a tapered locking dog. The concrete was then deposited in the forms by means of metal troughs. The pour was brought up evenly the entire perimeter of the shaft and vibrated simultaneously with an air-operated vibrator. By this procedure, concrete was poured at the rate of 8 to 10 cu. yd. an hr. at a distance of over 3,000 ft. below the collar of the shaft.

With the original three-compartment type of shaft, preparation for concreting involved tying an outer grid of ⅝-in.-round reinforcing steel on 24-in. centers, and an inner grid on 8- or 12-in. centers, depending on observed ground pressure on the sets. On several occasions, pressure necessitated an outer grid of 20-lb. rails on 24-in. centers. Where pressure was not extreme, the outer grid was eliminated and the inner grid put on 12-in. centers. After the installation of the steel, a floor was put in and two sets were lagged off with 2-in. lagging on all four sides, thus completing pouring preparations. A minimum thickness of 18 in. of concrete was allowed with the inner grid of steel 3 in. from the lagging and the outer 15 in.

With the new modified type of shaft, several changes in concreting procedure were necessary. First, the reinforcing steel on the sides of the shaft was reduced in the inner and outer grids to 12-in. and 24-in. spacings, respectively, but only the inner 12-in. grid was used on the concave ends of the shaft. The outer 24-in. grid on the sides was eliminated more frequently with the modified shaft. This required, on the average, 20 to 40 per cent less steel than the former design. Second, the removable steel forms, designed in panels with the heaviest piece weighing about 150 lb., were installed with tapered steel pins and braced against the shaft posts and end plates. The bottoms of the steel forms had inlets for the reinforcing steel and were set at 45 degrees for the joint of the following pour. The top of the joint was 18 in. above the set, which required the top of the forms to have a 4-in. lip so that concrete could be deposited for the final part of the pour making the joint. End blocking was removed from two sets for the installation of the removable forms. A floor was put in on the sides and the sets lagged off in the usual manner.

Shaft Advance

From July, 1953, through February, 1954, footage in the unconcreted part of the shaft averaged 140 ft. a month. In the concreted unmodified part, advance averaged 38 ft. a month, with December, 1954, being the best month when 70 ft. were sunk and 52 ft. concreted. Footage per month in the concreted modified section averaged 93 ft., with the best advance in May, 1955, when 128 ft. were sunk and 140 ft. concreted.

In the writer's opinion, the worst ground in the shaft was encountered before the modified shaft design was adopted. Tl is greatly affected monthly footage advance. The smaller semi-elliptical shaft contributed to closer control over poor ground conditions, and resulted in the successful completion of the project. In addition, the modification of Shaft No. 3 effected an important savings in time and a substantial reduction in the costs.

In the preparation of this article, the writer wishes to acknowledge the valuable suggestions offered by Arthur P. Nelson, general manager of Minas de Matahambre, S.A., and William J. Bridgeman, project supervisor.

NEWS NOTES

SCHRAMM PORTABLE DRILLING RIG

A new kind of portable drilling rig has been developed by Schramm, Inc., West Chester, Pennsylvania. According to the manufacturer, the Schramm Rotadrill on Pneumatractor brings to rock drillers all the advantages of rotary rock drilling with compressed air – clean, fast holes; fast setup; and longer bit life.

The manufacturer says that because the Rotadrill on Pneumatractor is a complete, self-contained unit, self-propelled and self-powered, it boasts a low initial cost. The unit can drill a 4¼-in. hole to a depth of 500 ft.; one-man operation is possible because all controls are arranged in one bank, adjacent to the mast. Special-weight boxes and dual rear wheels on a 125-c.f.m. heavy Pneumatractor provide 10,000-lb. down pressure. Normal compressed air drilling pressures of 20 to 30 p.s.i. can be instantly increased for dewatering or breaking out blockages, the manufacturer points out.

Standard rotative head has 75-r.p.m. output and can be throttled down to complete stall while maintaining constant torque. Heavy-welded structural steel mast, lowered for traveling between jobs, can be operated at various angles for sloping holes.

Illustrated Bulletin PR-55 describes this new drilling unit in detail. Write to Schramm, Inc., 900 East Virginia Avenue, West Chester, Pennsylvania.

TRUCK-MOUNTED AUGER DRILLS

Horizontal truck-mounted and self-propelled McCarthy auger drills for earth and rock boring are featured in the 4-page Bulletin M-105, published by The Salem Tool Company, South Ellsworth Avenue, Salem, Ohio.

Powered by gasoline engine, diesel, or electric motor, the drills bore up to 12-in.-diameter holes to depths of 150 ft. in earth formations. Crosswise or lengthwise truck mountings, individually operated leveling jacks, heavy-duty main frame and transmission are versatile features. Drilling height ranges from 4½ to 7 ft.

For more detailed information, communicate with The Salem Tool Company, South Ellsworth Avenue, Salem, Ohio.

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INGERSOLL-RAND'S HYDRA-BOOMS

Ingersoll-Rand announces a new 12-page Hydra-Boom bulletin covering its complete line of hydraulic booms for use in the construction and mining industry. The new bulletin thoroughly covers Hydra-Boom applications, their advantages over wagon drills in construction work and over column-mounted drills in mining and tunneling, according to the manufacturer.

The bulletin contains information on booms mounted on tractors, tunnel jumbos, and self-propelled air-operated rigs. It also contains dimensioned coverage diagrams showing the area that can be covered by each boom, both vertically and horizontally. Information is given on special Jumbo mountings including a four-boom, self-propelled machine for drilling a face 40 ft. high underground. For a copy of the bulletin, Form 4162, write to Ingersoll-Rand Company, 11 Broadway, New York 4, New York.

X-TYPE ROK-BITS

Designed for use on the new, larger machines, Brunner & Lay offers the X-type, tungsten-carbide Rok-Bits.

Available in 3½-, 4-, and 4½-in. gauge sizes, to fit on 1½- and 2-in. drill rods, these bits are now made to fit directly on the steel of two machines, eliminating the use of expensive adapters. The manufacturer points out that the X-type Rok-Bits feature a new body design, new job-fitted carbides.

Descriptive Bulletin B-1 is available from Brunner & Lay, Inc., 9300 King Street, Franklin Park, Illinois.

NEW BUCYRUS-ERIE BULLETIN

A new 16-page bulletin (71-B-1) describing the Bucyrus-Erie 71-B shovel (3-cu. yd. capacity) is now available. Pictorially illustrated, the booklet gives a complete description of the machine's features along with a list of general specifications.

According to the manufacturer, Model 71-B is readily convertible to dragline, clamshell, or lifting crane and incorporates the basic engineering features and field-proved advantages of the company's current line of general-purpose excavators. It is powered by a six-cylinder GM diesel engine equipped with Torcon torque converter; diesel engine with conventional drive is also available.

Other features described in the bulletin are: positive twin-rope balanced crowd with rectangular inside dipper handle; strong, light boom; fully independent boom hoist; full air control (not just air assist) except for drum brakes and swing and propel jaw clutches; steering clutches and friction digging brakes spring-set and air-released; one-piece cast steel revolving frame; choice of four A-frames; 12 conical hook rollers; and four optional crawler mountings.

Bulletin 71-B can be obtained by writing Bucyrus-Erie Company, South Milwaukee, Wisconsin.

ELECTRIC SHOVEL CONTROL

Harnischfeger Corporation, Milwaukee, Wisconsin, offers electronic control as standard equipment on P&H electric shovels. The manufacturer reports that the new control governs all shovel-operating motions, and marks the first time full electronic control has been applied to large excavating equipment.

Fully tested and proved under all field conditions, this new electronic control offers many advantages, according to the manufacturer. More rapid signal response from controllers is achieved as well as greater ease of operation. Shovel cycle time is reduced because of faster response and the fingertip ease of control.

P&H electronic control is offered as standard equipment on P&H electric shovels from P&H Model 1400 (4½-yd. capacity) through the P&H Model 1800 (8-cu. yd. machine).

Additional information may be obtained by writing to Harnischfeger Corporation, Electric Shovel Division, 4620 W. National Avenue, Milwaukee 46, Wisconsin.

NEW EUCLID SCRAPERS

The Euclid Division of General Motors Corporation is now in production on two new overhung engine-type scrapers. Each has a struck capacity of 18 cu. yd. and utilizes Allison Torqmatic Drive consisting of torque converters and semiautomatic transmission.

The manufacturer states that Torqmatic Drive completely eliminates clutching and permits the operator to change from one speed range to another under full power. The manufacturer also states that Torqmatic Drive provides a constant, smooth flow of power to the drive wheels and automatically provides the power needed for varying conditions of loading, hauling, and dumping. Both of these new scrapers are equipped with no-spin differentials to provide maximum traction by directing full torque to the drive wheel with the best footing.

Complete information and specifications are available from Euclid dealers or direct from Euclid at Cleveland 17, Ohio.

NORDBERG'S SYMONS V-SCREENS

Publication of Bulletin 243, a two-color bulletin describing the Symons V-Screen, is announced by Nordberg Manufacturing Company, Milwaukee, Wisconsin. This screen is specifically designed for fine screening, for sizing, dewatering, dedusting, cleaning, and washing. The manufacturer further states that it is unique in its construction and operating characteristics, and is the only screen that does not depend on gravity alone for its screening action.

Bulletin 243 tells how the entirely new screening action of the Symons V-Screen multiplies its screening effect by combining centrifugal and gravitational forces for high-capacity and sharp, single-cut, wet or dry separations. Details of construction and operation are given. Dimensions of the screen and three types of collection hopper bases are shown. Operational data from installations demonstrate successful application in sand and gravel, stone, coal, ore, slag, nonmetallic minerals, chemical, grain, and food-product plants.

Bulletin 243 is available upon request to Nordberg Manufacturing Company, Milwaukee 1, Wisconsin.

HIGH-STRENGTH WIRE ROPE

A new high-strength wire rope, which, according to the manufacturer, is at least 15 per cent stronger than the best grade of wire rope now being manufactured, has been announced by the American Chain & Cable Company, Wilkes-Barre, Pennsylvania.

The new grade of rope is expected to simplify the use of wire rope generally and to permit lighter weight equipment to be designed at lower cost. An average tensile strength of 300,000 p.s.i. has been achieved by the use of special precise analysis high carbon steel wire and improved processing, according to the manufacturer.

The preformed rope, to be known as VHS – very high strength – will be marketed by both the Hazard Wire Rope and American Cable Divisions. It has been widely tested in heavy-duty construction, mining, petroleum, and logging installations where its service life more than doubled that of existing cables, according to the American Chain & Cable Company.

In addition to 15 per cent greater tensile strength than improved plow steel, it is claimed that VHS cable is more wear-resistant and will keep its shape under pressure.

Additional information may be obtained by writing to American Chain & Cable Company, Wilkes-Barre, Pennsylvania.

NEW SAFETY HELMET

According to Mine Safety Appliances Company, Pittsburgh, Pennsylvania, workers on jobs that involve head-injury hazards are offered added protection in the new Skullgard plastic safety helmet.

Designed to offer extra protection in what has been described as the "danger zone" – the front, top, and back areas of a hat – the new Skullgard incorporates a special reinforcement in this zone's three vital areas.

MSA specialists report that new molding techniques, better materials, and improved production methods have added to the protection offered by previous Skullgards without increasing the hat's weight.

The Skullgard is high-pressure molded in one piece from hard, smooth, laminated plastic.

More detailed information may be obtained by communicating with Mine Safety Appliances Company, Pittsburgh, Pennsylvania.

NEW FACESHIELD

A clear acetate visor that gives excellent frontal and side face protection against abrasive particles, flying objects, and chemical splashes has been developed by Mine Safety Appliances Company, Pittsburgh, Pennsylvania.

Called the M-S-A Skullgard-Faceshield, it can be attached to any M-S-A protective hat without marring the hat and can be installed or removed in seconds. An aluminum pivot arm permits the shield to be swiveled up or down in any desired position. The visors are easily detached from the pivot arm for replacement.

A complete description of the new faceshield has been published in a two-color illustrated bulletin, Number 0302-4. Copies may be obtained from Mine Safety Appliances Company, 201 North Braddock Avenue, Pittsburgh 8, Pennsylvania.

INDUSTRIAL SEISMOLOGY

VIBRATION SURVEYS—BLASTING EFFECTS ANALYSIS

HAROLD H. WHITE

CONSULTING ENGINEER

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Mining Rock Salt 1000 Ft. Underground

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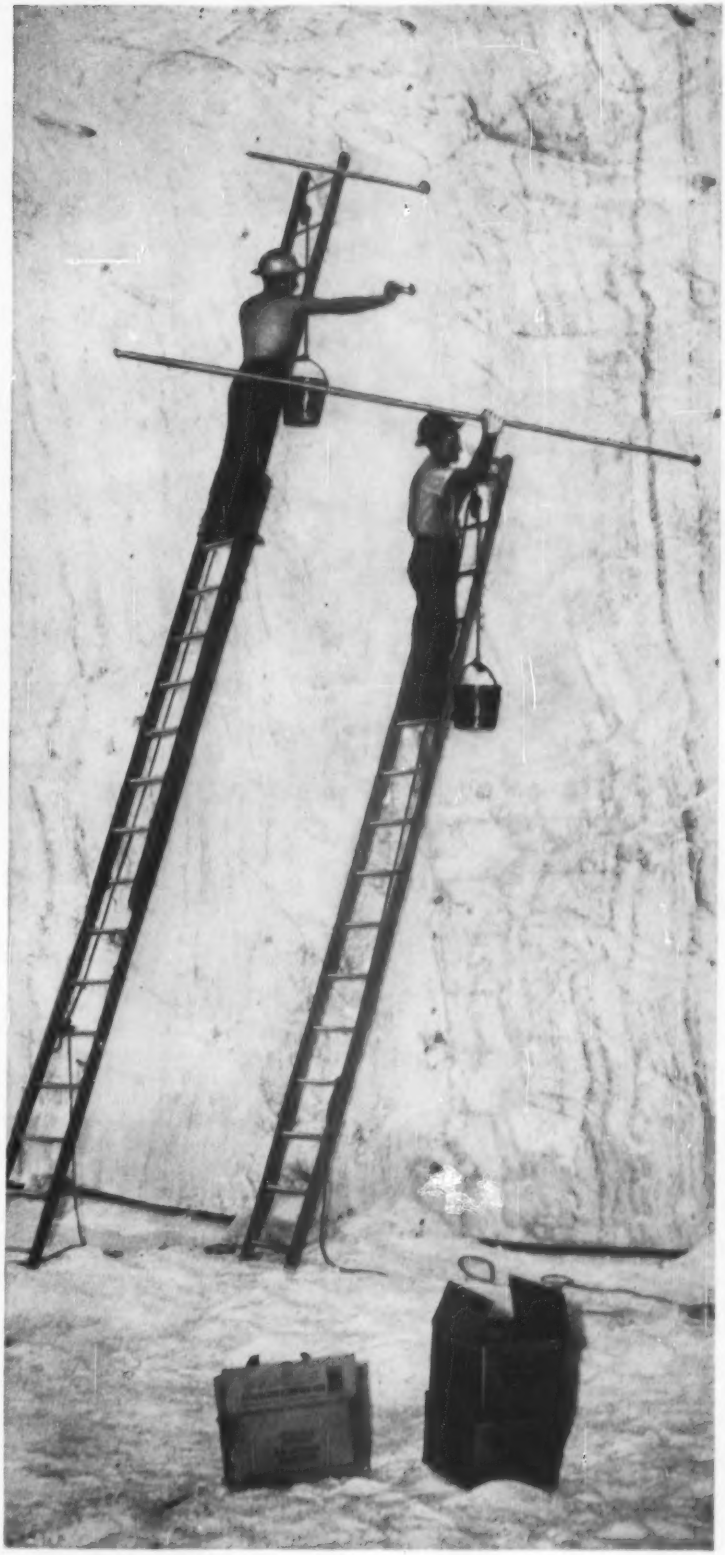

Using ladders, the blasting crew loads cartridges of Hercomite® into the upper rows of drill holes in a 24-ft. high working face 1,000 ft. underground in Jefferson Salt Company's mine in Louisiana.

Primed with regular and short-period delay electric blasting caps made by Hercules, the blasts produce excellent fragmentation, affording economical recovery by power shovels and uninterrupted processing operations in the plant on the surface.

The development, manufacture, and use of specialized types of explosives have been Hercules' business for over forty years. Our knowledge of explosives and blasting techniques is at your disposal in solving blasting problems in mining, quarrying, construction, or wherever explosives are used.

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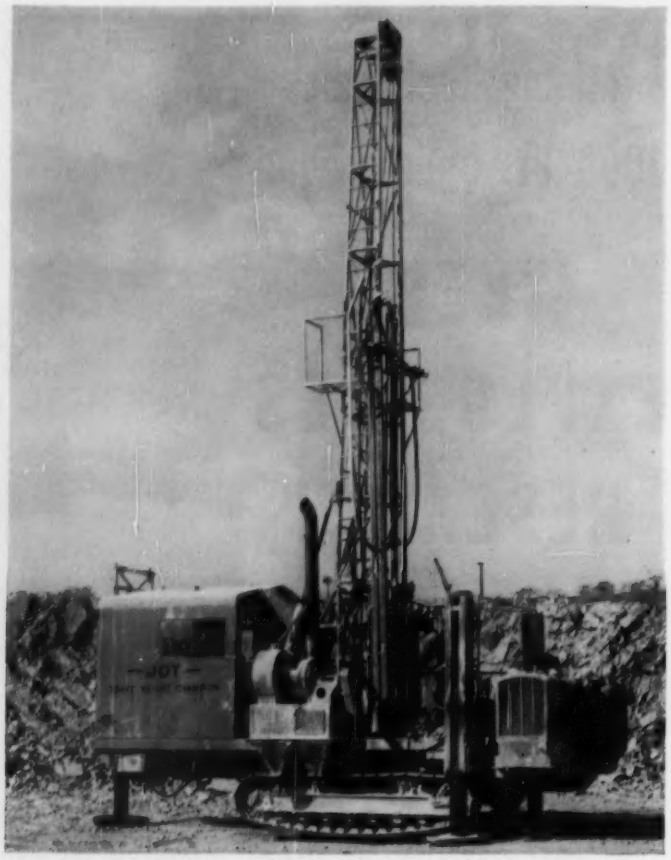
"...this JOY CHAMPION BLAST HOLE DRILL was so good We Bought TWO More"



"IT OUTDRILLS SEVEN CHURN DRILLS"
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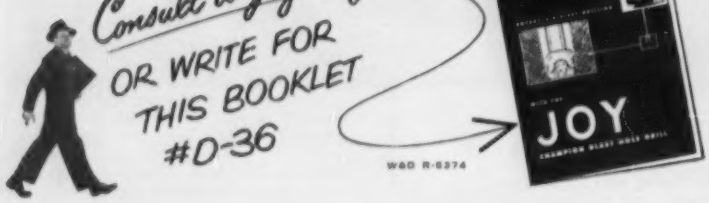
CONTRACT BLAST HOLE DRILLER
NORRISTOWN, PA.

"That's not all," states Contract Driller Charles Lauman. "Most of our drilling is in hard, tough dolomite with strata tilted at all angles and loaded with clay pockets and clay seams. We have found that the 58-BH Joy Champion will drill a smoother vertical hole wherever the hole is spotted. This eliminates toes and gives our customers a straight vertical face. We're convinced it's the best machine for the job—so much so that we bought two more on the strength of this one's production."

The Joy Champion DRILLS DRY with a tri-cone roller bit which continuously pressure-cuts the rock. An air-blast, forced down the drill pipe and through the bit, cools the bit and forces cuttings to the surface.

The Champion drills straight, smooth-walled, easily loaded holes up to 7⅞" diameter and to any quarrying depth required. It moves fast between holes and sets up quickly for drilling on three hydraulic jacks. Two Champion models—Mediumweight and Heavyweight—can be furnished with either electric or diesel drive. ***Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.*** In Canada: *Joy Manufacturing Company (Canada) Limited, Galt, Ontario.*



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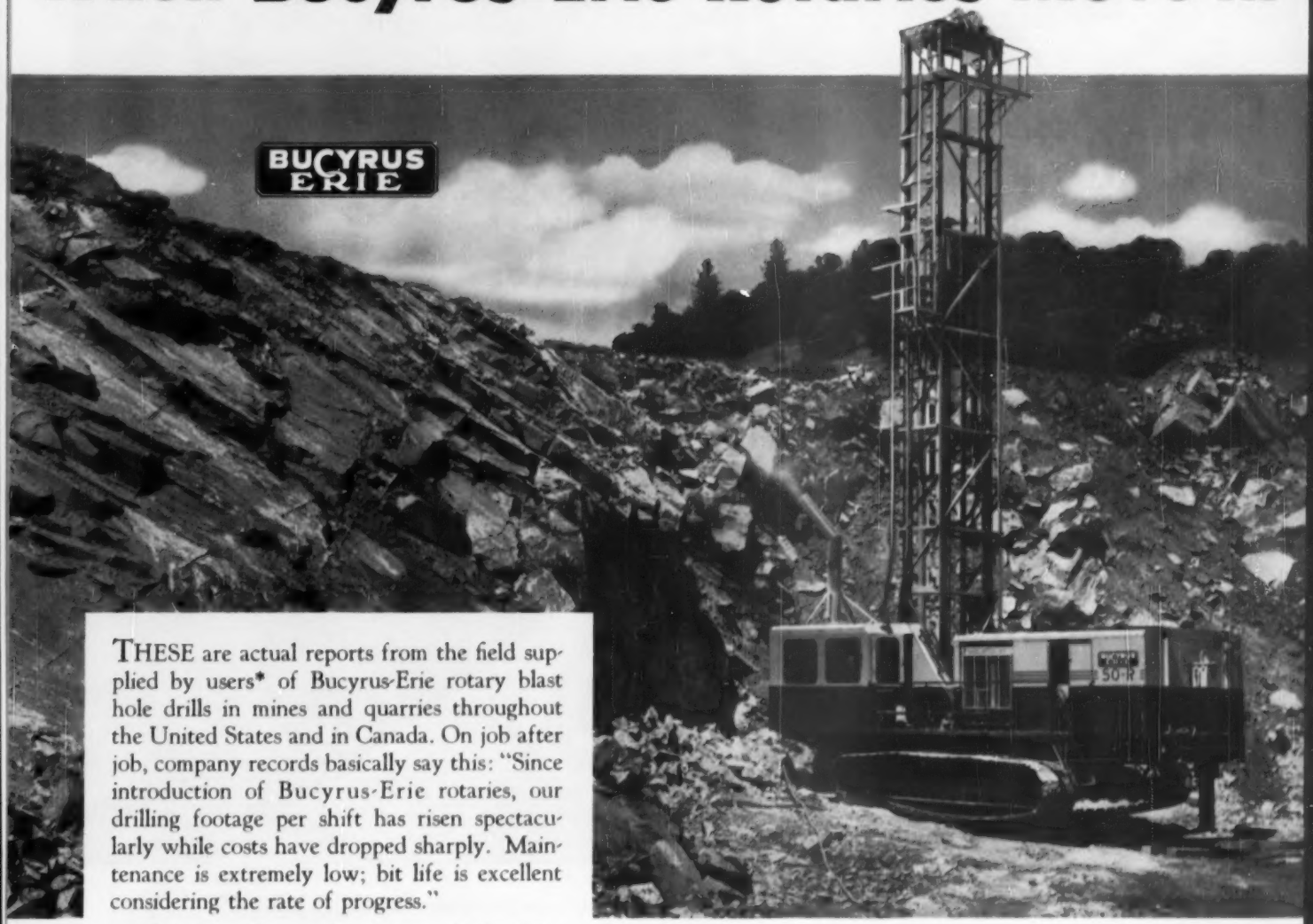
Drilling Costs Go Down When Bucyrus-Erie Rotaries Move in



THESE are actual reports from the field supplied by users* of Bucyrus-Erie rotary blast hole drills in mines and quarries throughout the United States and in Canada. On job after job, company records basically say this: "Since introduction of Bucyrus-Erie rotaries, our drilling footage per shift has risen spectacularly while costs have dropped sharply. Maintenance is extremely low; bit life is excellent considering the rate of progress."

Consider the performance obtained by these owners in the light of your own drilling requirements. Then let us give you the complete story on Bucyrus-Erie rotary drills — the 50-R, with electric power, for drilling 9⅞ to 12¼-in. holes; the 40-R, with diesel-electric or full electric power, for drilling 6¾- to 9-in. holes.

** Names will be supplied on request.*

In an Indiana Coal Mine a Bucyrus-Erie rotary drilled a total of 1,325 feet in a single 6¾ hour shift. Overburden consisted of a medium-hard sandstone with overlay of hard shale. This record was achieved with 10⅞-in. holes averaging 40 feet in depth. Thirty-three holes were drilled in one day's work; average footage drilled was 196 feet per hour.

At a Canadian Iron Ore Property progress of 60 feet per hour, drilling both 9-in. and 9⅞-in. holes in hard iron ore; was reported.

In a Pennsylvania Anthracite Strip Mine the material was conglomerate, granite, and sandstone, very hard and abrasive, and badly broken up and fissured. A 50-R drilled 9⅞-in. hole at the rate of 24 feet per hour. During 256 hours working time, the rotary put down 6,125 feet.

A Cement Company in California, drilling in hard limestone formations, reported a drilling cost of 76 cents per foot of 9⅞-in. hole with their Bucyrus-Erie rotary as compared to $2.52 per foot of 9-in. hole with other drills.

Another Pennsylvania Hard Coal Stripping Operation recorded 27,750 feet of 12¼-in. hole drilled during a total of 1,458 hours working time. Material was hard and medium sandstone, shale, conglomerate, and slate. Footage per hour was 19 feet, with holes averaging 70 feet in depth. Average bit life was 1,762 feet.

23855C

BUCYRUS-ERIE COMPANY

South Milwaukee, Wisconsin

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Explosives Research Pays Off

Blasting trenches in hard granite formations to install a pipeline in Southern California called for engineering skill, operating know-how, and a knowledge of explosives.

Over hills and valleys and across rivers and gorges, pipelines provide safe, sure, economical means of transportation for petroleum, natural gas, water, and other mineral resources. When rock is encountered, blasting crews with specialized explosives take over. Here is where explosives research pays off.

Continuous research and extensive knowledge of field conditions have been Hercules' business for more than forty years. Hercules technical representatives welcome opportunities to discuss problems and help in the selection of the right explosives and the most efficient methods for use in mining, quarrying, construction, and exploration projects.

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XR55-3

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Use this HALF HITCH for Plain and Reinforced Primacord. Draw it up as tight as you can, and be sure the Branch Line leads off at a RIGHT ANGLE to the Trunk Line.

Stray ELECTRICAL CURRENTS DON'T DETONATE PRIMACORD

Unwanted electrical energy is on the increase. The sources are several: a bolt of lightning several miles away, static, radio transmitters, galvanic action, transmission lines, power cables to electrically operated equipment . . . Under certain conditions any of these sources could set off a blast prematurely.

Not so when the holes are primed and hooked up with Primacord. For Primacord is the *insensitive* detonating agent. It cannot be set off by sparks, friction, ordinary shock, stray currents – and *even a direct hit by lightning failed to detonate it!*

Only when the blasting cap is attached at the firing end of the Primacord trunk line is the blast ready to go. And, of course, you do this only when everything's all set.

For more information see your Explosives Supplier, or write to

THE ENSIGN-BICKFORD COMPANY • SIMSBURY, CONNECTICUT

Primacord – Quarrycord – Ignitacord® – Safety Fuse Blasting Accessories – Established 1836

To connect a Branch Line of Plastic Reinforced or Plastic Wire Countered Primacord with the Trunk Line

use this DOUBLE HITCH in the textile-covered Primacord Trunk Line. *Draw it up as tight as you can, and make sure that the Branch Line leads off at a RIGHT ANGLE to the Trunk Line.*

PRIMACORD®

DETONATING FUSE

PROVED AND APPROVED

To lengthen a Trunk Line

of Plain or Reinforced Primacord, tie a SQUARE KNOT. *Draw it up as tight as you can* – it won't slip back. Caution: don't use any knot in a hole – it might break or hang up explosives when loading.

To connect the Detonator with the Primacord Trunk Line

use FRICTION TAPE. You can detonate Primacord with fuse and cap or electric blasting cap. Lay the cap alongside of the Primacord with the business end of the cap pointing in the direction that the Primacord will detonate. Tape the two snugly together, so that you have a tight connection.

Cut the Primacord off the Spool Immediately

Make this a safety habit! As soon as you have taken off the length of Primacord you need for a down-hole or for a trunk-line, *cut it off the spool! Don't waste a second – do it now!*

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HARD HITTING TEAMWORK

...I-R Style

I-R WAGON DRILLS
powered by
GYRO-FLO Compressors
make an unbeatable

CONTRACTORS' COMBINATION

CARSET JACKBIT

Above you see a battery of eight Ingersoll-Rand Wagon Drills putting in 20 foot deep, 2¾ inch, near horizontal holes, in a 28 foot rock cut. Sustained full air pressure was provided by 600-cfm Gyro-Flo portable compressors shown in inset.

The recognized superior slugging and hole cleaning power of Ingersoll-Rand X71WD Wagon Drills made them first choice for this recent major highway construction job. Gyro-Flo Rotary Compressors were used throughout because they provided air power at rock bottom costs. With no valves, pistons, rods or clutch to wear, maintenance is reduced to a minimum.

Ask your I-R representative about the many extra-value features of this cost-cutting combination. He can supply everything you need for drilling rock—from the Carset Jackbit all the way back to the compressor.

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